

# Bridge inspection technique using rope access

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## ABSTRACT

Bridge inspection is widely recognized as playing the most important role in the bridge maintenance system. Hanshin expressway inspects the bridges mostly every 5 years, however, there are some bridges that are very difficult to approach even though using bridge inspection vehicles or gondola lift vehicles. New inspection technique using rope access is applied to the bridge inspection especially for fatigue crack occurred on the orthotropic steel deck. Rope access inspection is widely employed for the structure where the inspection access path is only vertical. This research studies the applicability of rope access technique to the structure that needs horizontal access path. As a result of this study, rope access technique can apply to the inspection for fatigue crack on the steel bridge deck and also performs good inspection in terms of inspection time and cost.

## 1. INTRODUCTION

The Hanshin expressway is an urban expressway network in Osaka, Kobe and Kyoto in Japan and consists mostly of elevated bridges. Many of the bridges are equipped with catwalks for maintenance and attachments for scaffold suspension for repainting.

Bridge inspections performed on the Hanshin expressway are divided into four categories: initial, bi-monthly, regular and emergency inspections. The initial inspection is close visual inspection performed to determine initial condition of the structures and obtain the initial deficiency data for the life time maintenance. The bi-monthly inspection is performed visually from distance using binoculars underneath the bridge for the purpose of preventing harm to third parties. The regular inspection is performed at roughly 5 years intervals by closely accessing the bridge to detect damage in early stage, assessing the level of detected damage, and preparing for the repair. The emergency inspection is

performed in case of disaster or accident complements daily and regular inspections.

One of the current problems of maintenance of Hanshin expressway is fatigue damage in steel decks. Steel decks with fatigue damage are deformed locally as the rigidity deteriorates with the development of cracks, therefore immediate measures are needed since such local deformation can damage pavement or affect driving condition. It is difficult to detect fatigue cracks in early stage because it often starts in welds of complicate-assembled members and is small in width. Therefore, fatigue damage inspection usually requires experienced and knowledgeable inspection engineers familiar with fatigue damage to inspect the structures within a hand-reach distance.

Inspection of all steel deck bridges started in 2003 on the Hanshin Expressway after fatigue cracks were found in steel decks that is the upper flange of the box girders during periodic regular inspection in 2001. Steel decks of most of the bridges were inspected using catwalks, ladders, gondola lift vehicles and bridge inspection vehicles. However, the members inaccessible by these ways are left uninspected. Most of these places are located over a river, sea and in the vicinity of a ramp, junction, toll gate or parking area. For such members, temporary scaffolding is erected conventionally just for inspecting.

However, erection of temporary scaffolding requires many permission from concerned parties and takes time from planning to implementation; which means low speed and high cost.

As a solution to the difficult access problem, rope access technique was considered for the current steel deck inspection project. Rope access is a technique to access to structures using ropes as



Photo 1, The bridges inaccessible by gondola lift vehicles or bridge inspection vehicles

the means of support. There have been several cases of its application in inspection of tall piers and towers. This technique was also used on the Hanshin Expressway for inspecting main towers of a cable stayed bridge.

There were two difficulties for applying rope accessed inspectors for steel deck inspection. One is the travel direction. Rope-accessed inspectors travel primarily in the vertical direction in pier and main tower inspections; however they need to travel horizontally in the current steel deck inspection. Therefore, means of horizontal travel was developed for using rope access technique in steel deck inspection. The other one is the lack of experience of fatigue crack detection technique. Therefore, education program was developed and carried out with examples taken from actual damage detected in the past inspection.

This paper reports application and development of the rope access technique for inspecting fatigue damage in steel deck of existing expressways in service.

## **2. DEVELOPMENT OF BASIC ROPE ACCESS TECHNOLOGY FOR BRIDGE INSPECTION**

### **(1) Rope access technique in horizontal direction**

In order to inspect steel decks using rope access technique, inspectors need to travel horizontally while keeping close to the underside of the steel decks. Since it was impossible to drive anchors into steel structures, clamps were examined as the support for traveling at first but failed because of the weight to be carried by the inspectors. Instead, scallops and hanger hooks equipped for



Photo 2, Work procedure of steel deck inspection by rope access technology

installment of scaffold for re-painting were used. The hanger hooks attached to the main girders for re-painting were used for longitudinal travel support, while transverse travel was supported by routing the ropes around the scallops at the corner of the web and flange plates. Transverse rib plates were spaced mostly at intervals of about 3 m, and the inspectors move these spaces between the ribs covering by extending arms from the ribs.

Photo 2 shows the work procedure. The arrows indicate the directions in which the inspector travels: longitudinal direction in red; and transverse direction in blue.

## (2) Fatigue crack detection

Rope access is a special technique which is extremely difficult to master for ordinary inspectors. These specialist workers are excellent in rope access operation but lack of inspection of structures. Since they had no experience of performing steel deck inspection, preparatory education was provided to them before the field test so that expected inspection accuracy could be achieved. The education program was focused especially on steel decks, with examples taken from actual damage detected in the past.

Inspection accuracy was verified by having specialist workers to inspect the same area where periodic inspection was performed by ordinary inspectors one year ago and comparing the both results. The specialist workers carried out the field test inspection, without being notified of the results of the previous inspection.

# 3. FIELD TEST VERIFYING THE ROPE ACCESS TECHNOLOGY

## (1) Inspection party

The field team consisted of four specialist workers, one security personnel, and two site supervisors who were specialists of bridge engineering. The four inspectors were divided into two pairs, and each one was instructed to operate only within a range visible from the paired partner. The site supervisors nearby and supervised the work and instructed the inspectors. Transceivers were used for communication between the site supervisors and the inspectors.

## (2) Test field

The field test area was the center span of a 3-span continuous steel deck box girder bridge on the Wangan Route of the Hanshin Expressway, excluding the interior of the box girders.

The span length was 111 m, and inspection area was about 2,100 m<sup>2</sup>. The Wangan Route which links bay areas in Osaka and Kobe was built on soft reclaimed lands. Steel decks were adopted for minimizing dead load of the structures. Being located close to coastal facilities, the route plays an important role in land transportation. Heavy traffic of container trailers and large vehicles causes severe condition for structures. The current inspection area was found to have weld cracks at four locations in steel deck plates and longitudinal ribs during the regular inspection performed one year ago.



Photo 3, Test field location

#### 4. FIELD TEST RESULTS

##### (1) Inspection accuracy

Figures 1 and 2 show the results of the periodic inspection of one year ago and those of the current field test inspection, respectively. Fatigue damage was found at four locations during the previous inspection, and the current field test inspection using rope access technique detected all of them successfully and also new fatigue damage at another location. Comparison between the previous and the current inspection results revealed that the previously found fatigue damage has developed to three times the original size at the maximum in one year. The inspection accuracy of the field test was comparable to that of the periodic inspection.

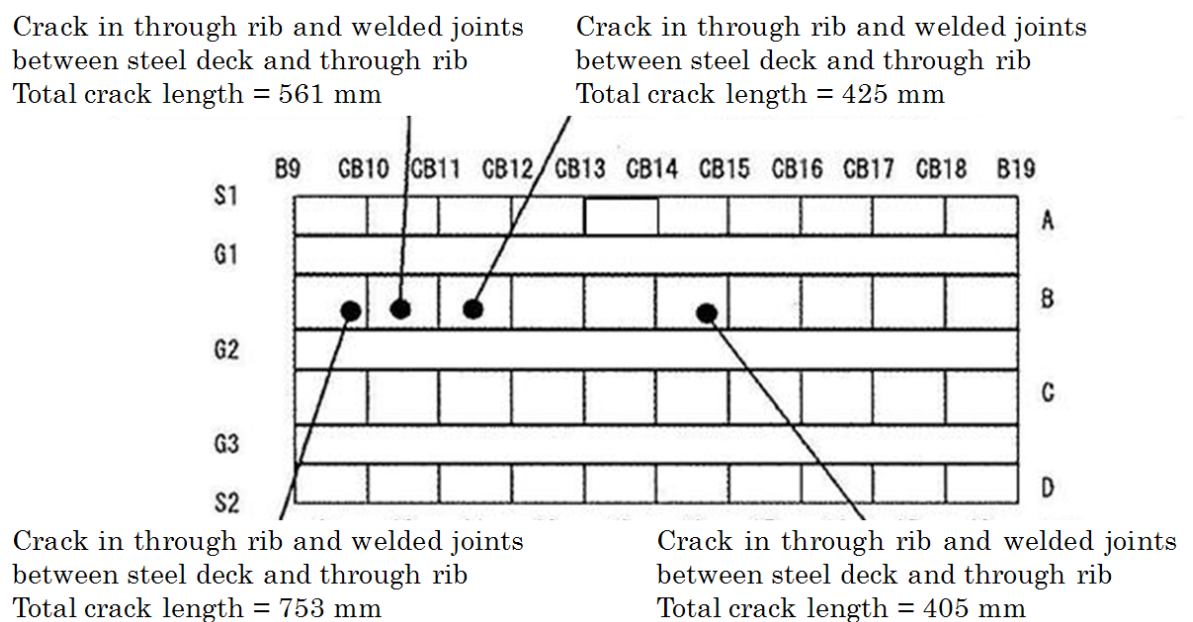


Figure 1, Inspection result of one year ago



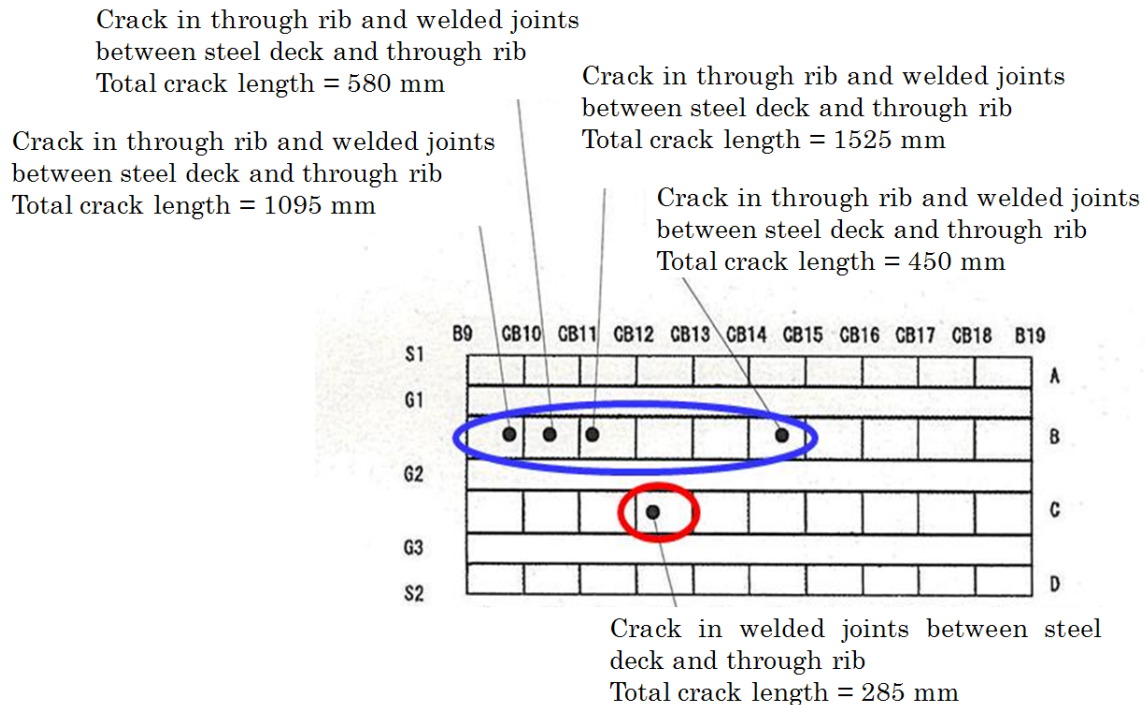


Figure 2, This field test result

## (2) Work speed

Photo 4 shows a view of the operation of inspection. Figure 3 shows the inspection area specified for the 5 work days. The shaded portions indicate the area actually inspected. About 1600 m<sup>2</sup> was inspected in the 5 work days, with an average of 320 m<sup>2</sup> per day. The work volume was influenced by the shape of the main girders, cross beams, transverse ribs, scallops, catwalks, and drainage pipes.

The field test provided approximate work speeds and also revealed the fact that various site factors including catwalks, attachments and span configurations had significant influence on work speeds.

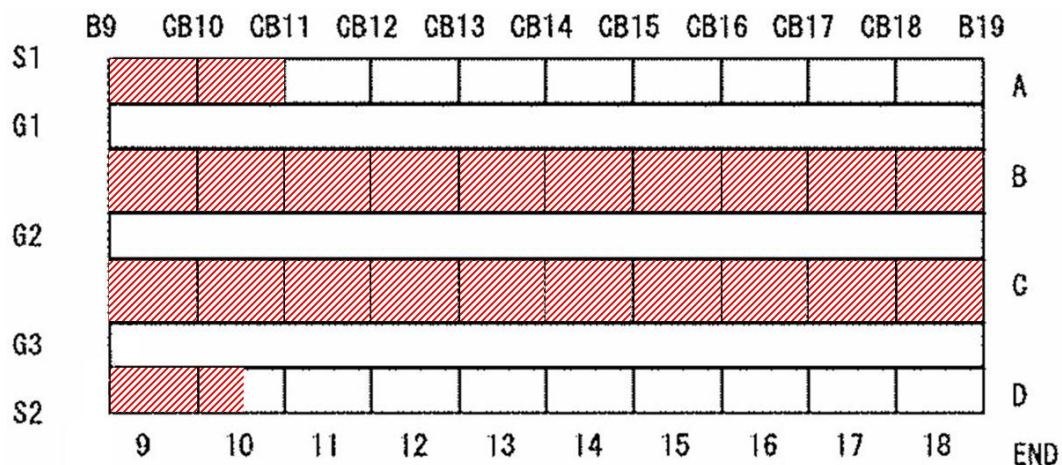


Figure 3, This test location of five days.



Photo 4, Conditions of inspection

### (3) Cost

Cost of the inspection using rope access technique was less than a half that of the ordinary inspection with scaffolding erection. This will greatly contribute to the reduction of inspection costs. The inspection by rope access was also found to cost about 1.5 times the inspection using aerial vehicles. Figure 4 shows a decision-making flow chart for inspection techniques. Basically, inspection should be performed using aerial vehicles and bridge inspection vehicles. Temporary scaffolding should be erected for inspecting a large area inaccessible by aerial vehicles or bridge inspection vehicles. Rope access technique should be employed for inspecting a small area with access difficulty.

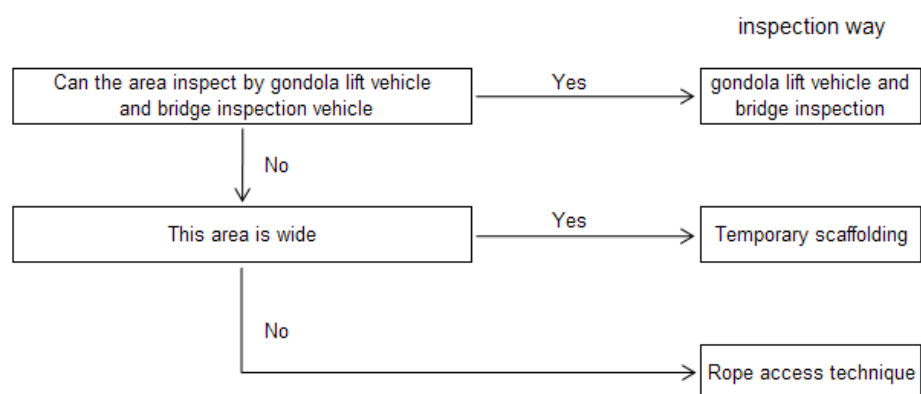


Figure 4, Decision-making flow chart for inspection ways

## 5. APPLICATION TO STRUCTURES IN SERVICE

With the problems with rope access solved by the field test, the technique was tested on the structures in service. Steel deck inspection was carried out on 33 spans or about 30,000 m<sup>2</sup> in total using rope access technique, and fatigue damage was detected at 54 locations, at accuracy comparable to ordinary inspection.

Table1, Result of inspection in service

Inspection spans	33 spans
Inspection an area	About 30,000m <sup>2</sup>
Detected cracks	54 cracks
Detected cracks in spans	15 spans



Photo 5, The one location that inspected by rope-access-technique





Photo 5, The one of detected crack

## 6. CONCLUSION

It takes a considerable number of days and cost to reach difficult areas by conventional instruments during inspection of structures. Field test of steel deck inspection was carried out to examine applicability of rope access technique to these areas with access difficulty. The major findings of the field test are summarized below.

- Rope access technique was found adequately applicable to the access to steel deck bridges.
- About 1600 m<sup>2</sup> were inspected in 5 days, with an average of 320 m<sup>2</sup> per day. Work speed was significantly influenced by site factors such as locations, catwalks and drain pipes. Since daily work volume fluctuates, it is necessary to fully understand the site conditions for proper schedule control.
- Cost of the inspection using rope access technique was about a half that of the close inspection with scaffolding erection. Rope access is more advantageous at smaller inspection areas.
- Comparison between the field test inspection results and the inspection results of one year ago showed that inspection using rope access technique had a comparable accuracy to periodic inspections.

Based on this study Rope access technology is found to be a very powerful technique for steel deck crack detection.

## **REFERENCES**

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